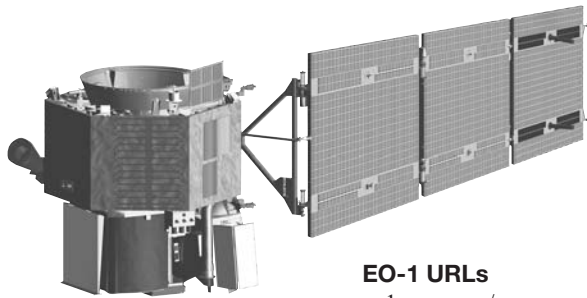


EO-1

Earth Observing-1



EO-1 URLs

eo1.usgs.gov/
eo1.gsfc.nasa.gov/

Summary

EO-1 is a one-year technology validation / demonstration mission designed to demonstrate new technologies and strategies for improved Earth observations. The satellite contains three observing instruments supported by a variety of newly developed space technologies.

Instruments

- Advanced Land Imager (ALI)
- Hyperspectral Instrument (Hyperion)
- Linear Etalon Imaging Spectral Array (LEISA)
- Atmospheric Corrector (LAC)

Points of Contact

EO-1 Project Scientist: Stephen G. Ungar, NASA
Goddard Space Flight Center

Other Key Personnel

EO-1 Program Scientist: Garik Gutman, NASA
Headquarters

EO-1 Mission Director: Dan Mandl, NASA Goddard
Space Flight Center

Mission Type

Earth Observing System (EOS) Technology Demo
(New Millennium Program)

Launch

Date and Location: November 21, 2000, from
Vandenberg Air Force Base, California

Key EO-1 Facts

Orbit:

Type: Sun-synchronous
Equatorial Crossing: 10:01 a.m.
Altitude: 705 km
Inclination: 98.2°
Period: 98.8 minutes
Repeat Cycle: 16 days

Dimensions: 2 m height × 2.5 m diameter

Mass: 529 kg

Power: 300 W

Design Life: 18 months; EO-1 is well beyond its
planned mission life and is still functioning

Downlink: X-Band (105 Mbps), Sioux Falls,
Svalbard, Alaska, Hobart (Australia)

Note: Part of the Morning Constellation of
satellites, lags one minute behind Landsat 7

Contributors

ALI: MIT/Lincoln Laboratory, NASA GSFC

Hyperion: TRW, NASA GSFC

LAC: NASA GSFC Applied Engineering and
Technology Directorate (AETD)

Relevant Science Focus Areas

(see NASA's Earth Science Program section)

- Carbon Cycle, Ecosystems, and Biogeochemistry
- Earth Surface and Interior

Related Applications

(see Applied Sciences Program section)

- Agricultural Efficiency
- Air Quality
- Aviation
- Carbon Management
- Coastal Management
- Energy Management
- Homeland Security
- Public Health
- Water Management

EO-1 Mission Goals

- Validate and test new technologies that could provide
significant cost reductions and improved performance
for future Landsat missions.

- Provide a science-grade space-borne hyperspectral instrument, thus providing a new class of Earth observation data for improved Earth surface characterization.
- Provide the first space-based test of an onboard atmospheric corrector for increasing the accuracy of surface reflectance estimates.

EO-1 Extended Mission Goals

- Sustain and enhance U.S. Geological Survey (USGS) and NASA research and development toward applications of hyperspectral and pushbroom multispectral data within the U.S. research and operational user communities.
- Promote opportunities within the remote sensing community to apply evolving imaging technology for government, scientific, and industry applications.
- Provide greater insight into potential commercial developers' prototype instrument performance.
- Add unique land remote sensing datasets to the USGS National Satellite Land Remote Sensing Data Archive.
- Characterize long-term performance of the EO-1 advanced technology sensors.

EO-1 Mission Background

EO-1 was developed as part of NASA's New Millennium Program (NMP) to demonstrate new technologies and strategies for improved Earth observations. The EO-1 satellite contains three observing instruments supported by a variety of newly developed space technologies. Instrument performances are validated and carefully monitored through a combination of radiometric calibration approaches: solar, lunar, stellar, Earth (vicarious) and atmospheric observations complemented by onboard calibration lamps and extensive pre-launch calibration. Techniques for spectral calibration of space-based sensors have been tested and validated with Hyperion. ALI and Hyperion instrument performances continue to meet or exceed predictions well beyond the planned one-year program.

The original EO-1 mission was successfully completed in November 2001. All data from the first year are currently available through the USGS Earth Resources Observation System (EROS) Data Center (EDC). As the end of the mission approached, the remote-sensing research and scientific communities expressed high interest in continued acquisition of image data from EO-1. Based on this user interest, NASA and USGS reached an agreement to allow continuation of the EO-1 Program as an Extended Mission.

The Extended Mission began in February of 2002 with the transfer of acquisition planning and scheduling, as well as data processing and distribution responsibilities, to EDC. As of early 2006, EO-1 is still fully functional and acquiring in excess of

Key ALI Facts

Heritage: ETM+ (Landsat 7)

Instrument Type: Linear Multi-Spectral Array

Scan Type: Pushbroom Sequential Sampling

Calibration: Pre-launch with on-orbit validation (solar, lunar, stellar, and vicarious)

Field of View (FOV): 3°

Instrument IFOV: 0.043 mrad (Multi-Spectral [MS]), 0.014 mrad (Panchromatic [Pan])

Transmission Rate: N/A

Swath: 37 km × 42 km (standard length), length can be adjusted

Spatial Resolution: 30 m (MS), 10 m (Pan)

Spectral Range: 0.43–2.3 μm

Dimensions: 0.9 m × 0.9 m × 0.7 m

Mass: 90 kg

Power: 100 W

Duty Cycle: Continuous (Data capacity limited by onboard storage)

Data Rate: 55 Mbps

Key Hyperion Facts

Heritage: Lewis Hyperspectral Imager (HSI)

Instrument Type: Grating Imaging Spectrometer Array

Scan Type: Pushbroom Simultaneous Sampling

Calibration: Pre-launch with on-orbit validation (solar, lunar, stellar, and vicarious)

FOV: 0.63°

Instrument IFOV: 0.043 mrad

Transmission Rate: N/A

Swath: 7.7 km × 42 km (standard length), length can be adjusted

Spatial Resolution: 30 m

120 scenes per week. All EO-1 data orders and tasking requests may be placed directly through the EDC website at eo1.usgs.gov. The EO-1 Extended Mission is chartered to collect and distribute Advanced Land Imager (ALI) multispectral and Hyperion hyperspectral products in response to Data Acquisition Requests (DARs). Under the Extended Mission provisions, image data acquired by EO-1 are archived and distributed by EDC and placed in the public domain.

EO-1 is part of the morning constellation of satellites, which also includes Terra, Landsat 7, and Satellite de Aplicaciones Cientificas-C (SAC-C). The EO-1 spacecraft follows Landsat 7 by approximately one minute. It is capable of cross-track pointing to allow potential imaging within one full adjacent Worldwide Reference System (WRS) path in each direction from the current flight path. Each ALI scene covers approximately one-fifth the width of a Landsat 7 Enhanced Thematic Mapper Plus (ETM+) scene. Hyperion scenes are acquired in strips, with a cross-track width of 7.7 km. Imagery from either sensor will have a user-specified along-track length of either 42 km or 185 km (equivalent to one full Landsat 7 ETM+ scene length).

Validating Revolutionary Spacecraft Technologies

The future of Earth science measurements requires that spacecraft have ever greater capabilities packaged in more-compact and lower-cost spacecraft. To this end, EO-1 tests five new technologies that will enable new or more cost-effective approaches to conducting science missions in the 21st century. These are: the X-band Phased Array Antenna, used for downlinking data gathered by the EO-1 science instruments; Enhanced Formation Flying, an autonomous, onboard, relative navigation and formation-flying control; the Pulsed Plasma Thruster, used for fine-attitude precision control; the Lightweight Flexible Solar Array, an advanced photo-voltaic solar array that utilizes a lightweight solar blanket and a shockless, shaped-hinge-deployment mechanism to achieve two-to-three times the specific power over conventional solar arrays; and the Carbon-Carbon Radiator, which has superior thermal radiating properties over conventional materials.

Other EO-1 Technology Challenges

The EO-1 imaging instruments presented a significant challenge to traditional spacecraft development. Because of EO-1's high-rate imaging (almost 1 gigabit per second (Gbps) when all three instruments are on), a specific subsystem on the EO-1 observatory needed to be designed and crafted to handle the data rate while still maintaining flight constraints of compact size and low power usage.

Although not officially part of the NMP/EO-1 validation list, the Wideband Advanced Recorder Processor (WARP) is a solid-state recorder with capability to record data from all three instruments simultaneously and store up to 48 Gbits (2–3 scenes) of data before transmission to the ground. WARP's compact design, advanced solid-state memory devices (3-dimensional RAM stacks) and packaging techniques enable EO-1 to collect and downlink all recorded data.

Key Hyperion Facts *(cont.)*

Spectral Range: 0.43–2.5 μm

Dimensions: 0.39 m \times 0.75 m \times 0.66 m

Mass: 49 kg

Power: 51 W

Duty Cycle: Approximately 50% (maximum power-on duration 50 minutes)

Data Rate: 221 Mbps

Key LAC Facts

Heritage: Lewis Atmospheric Corrector

Instrument Type: Linear Etalon Imaging Spectral Array

Scan Type: Pushbroom Sequential

Calibration: On-Orbit

FOV: 15°

Instrument IFOV: 0.354 mrad

Transmission Rate: N/A

Swath: 185 km \times 195 km

Spatial Resolution: 250 km

Spectral Range: 0.9–1.6 μm

Dimensions:

Electronics Module: 25 cm \times 23 cm \times 18 cm

Optics Module: 19 cm \times 18 cm \times 14 cm

Mass: 10.5 kg

Power: 15 W (48 W peak), < 15 W orbit average

Duty Cycle: Approximately 50% (maximum power-on duration 24 minutes)

Data Rate: 189 Mbps

Instrument Descriptions

The three remote-sensing instruments on the EO-1 observatory are the Advanced Land Imager (ALI), the Hyperion Imaging Spectrometer (Hyperion) and the Linear Etalon Imaging Spectral Array (LEISA) Atmospheric Corrector (LAC). All three instruments employ a pushbroom data-acquisition method and operate within the 0.4–2.5- μm spectral range.

ALI

Advanced Land Imager

The ALI instrument is a multi-spectral pushbroom radiometer designed to test concepts for Landsat follow-on missions.

ALI features 10-m ground resolution in the panchromatic (black and white) band, and 30-m ground resolution in its nine other multispectral bands. ALI uses a four-chip multispectral focal-plane array that covers seven of the eight bands of the current Landsat imagers. The swath width of ALI is 37 km. The Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL) developed ALI under project management from NASA GSFC, Greenbelt, Maryland. MIT/LL provides open access to U.S. industry regarding the design and performance of ALI with the explicit purpose of expediting technology transfer to the commercial sector.

Hyperion

Hyperspectral Imager

Hyperion scans the Earth through 220 different spectral channels and demonstrates hyperspectral imaging techniques that can be used to classify complex land ecosystems based on their spectral signature.

Hyperion provides a class of Earth observation data leading to improved surface spectral characterization. Hyperion capabilities provide resolution of surface properties into hundreds of spectral bands. Through 220 channels, Hyperion demonstrates the ability to perform detailed spectral mapping with high radiometric accuracy. In the future, an operational version of Hyperion will allow complex land ecosystems to be imaged and accurately classified. The swath width of Hyperion is 7.7 km and is aligned to view some of the same ground, at the same spatial resolution (30 m) as ALI, to aid in cross-comparisons between these instruments. Hyperion was developed by TRW, Redondo Beach, California, under project management from NASA GSFC.

LAC

Linear Etalon Imaging Spectral Array (LEISA) Atmospheric Corrector

LAC is a wedge imaging spectrometer that can be used to remove the effects of the atmosphere from surface pictures, thus improving imagery and hyperspectral-sensing capabilities.

LAC is an infrared camera. Images from LAC can be used to remove the effects of the atmosphere from surface pictures obtained by instruments such as ALI on EO-1 and ETM+ on Landsat. Observing the surface through the atmosphere is conceptually the same as viewing the bottom of a lake through cloudy water. LAC provides data on the amount of atmospheric water vapor. These data can be used to clear the view. LAC on EO-1 will be the first use of a dedicated instrument to perform this function on a real-time basis. This instrument will provide scientific return both in terms of improved imagery and hyperspectral sensing capabilities. It will also test a number of new technologies. Because LAC is small and adaptable to different spacecraft configurations, it is a bolt-on instrument, which can be attached to any future Earth-imaging spacecraft. Goddard Space Flight Center's AETD developed the LAC instrument. AETD will provide open access to U.S. industry regarding the design and performance of LAC, with the explicit purpose of expediting technology transfer to the commercial sector.

EO-1 References

EO-1 Special Issue of *IEEE Trans. Geosci. Remote Sens.*, June 2003.

EO-1 Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
ALI/Hyperion/LAC <i>ALI Data Set Start Date: March 16, 2001; Hyperion Data Set Start Date: May 1, 2001</i>			
ALI Radiometric	1R	Global	37 km × 42* km/ 16-day repeat
Hyperion Radiometric	1R	Global	7.7 km × 42* km/ 16-day repeat
LAC**	N/A	Global	185 km × 42* km/ 16-day repeat
<p>* 42 km is standard length of Data Products, but the length can be adjusted</p> <p>** LAC data were collected during the original mission but are not being collected or distributed during the extended mission—e.g., since 12/2001</p>			

EO-1 Data Products